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INT CL⁴ H04B 17/00

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(54) **Radio transponder apparatus**

(57) In a radio transponder apparatus a rectifier 11 converts a received radio wave into a DC power for a response logic circuit 12, a voltage comparator 21 compares an output voltage from the rectifier with a predetermined minimum operating voltage L for controlling a circuit 20 which activates one of components which constitute the radio transponder apparatus to start a response operation when the output voltage from the rectifier is not less than the minimum operating voltage. The circuit 20 may control the supply of DC power to circuit 12, the supply of response signal from circuit 12 to transmitter 15 or the supply of interrogation signals from receiver 14 to circuit 12. The output of comparator 21 may actuate a display 22 or an alarm. The apparatus avoids erroneous operation when the transponder is located beyond an optimal distance from an interrogating apparatus. The transponder may be an ID card or a product on assembly line.

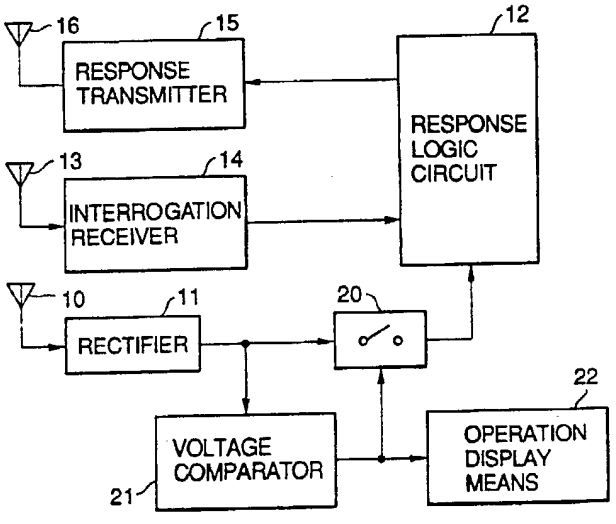

FIG.2

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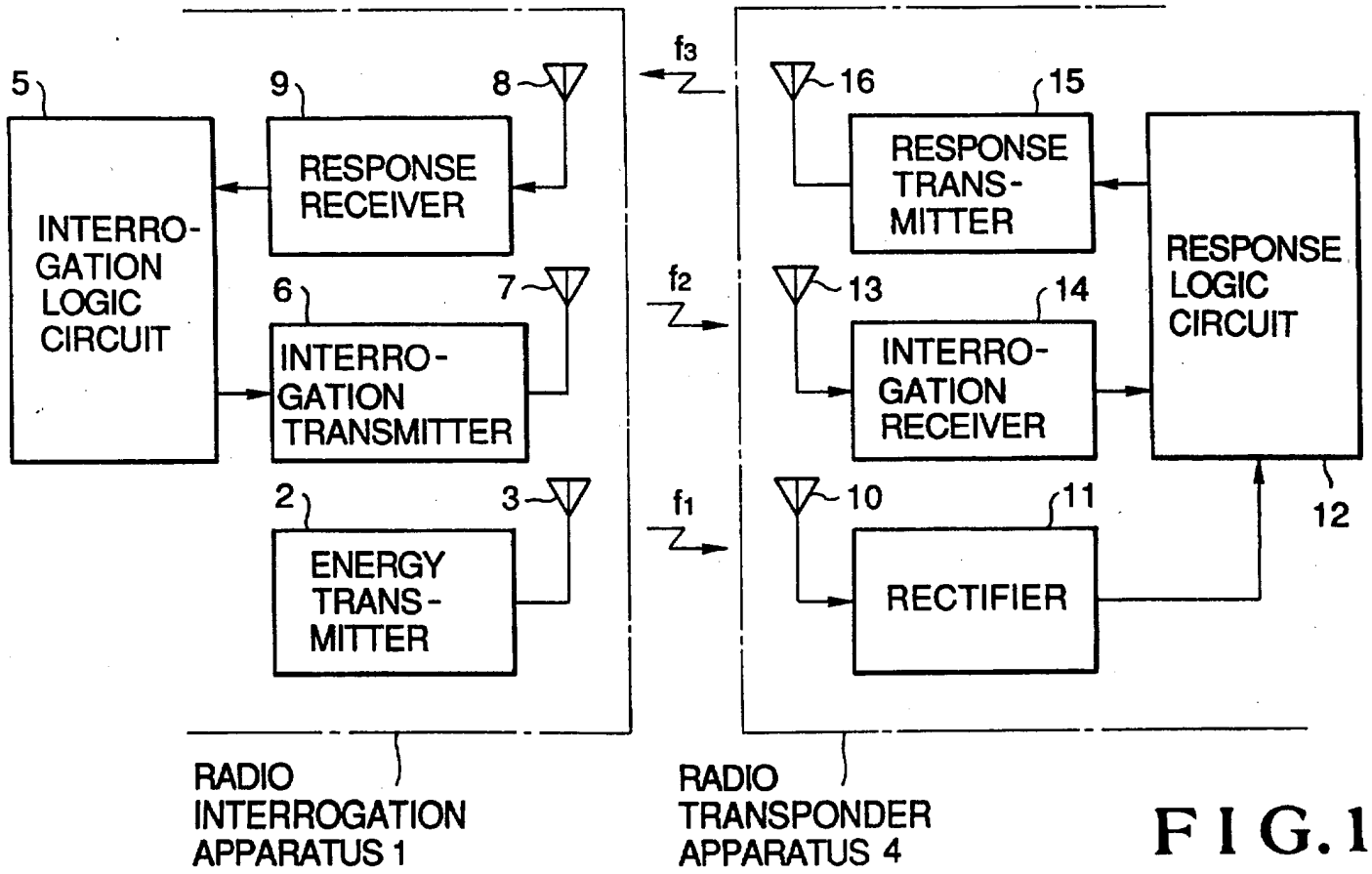

FIG. 1
(PRIOR ART)

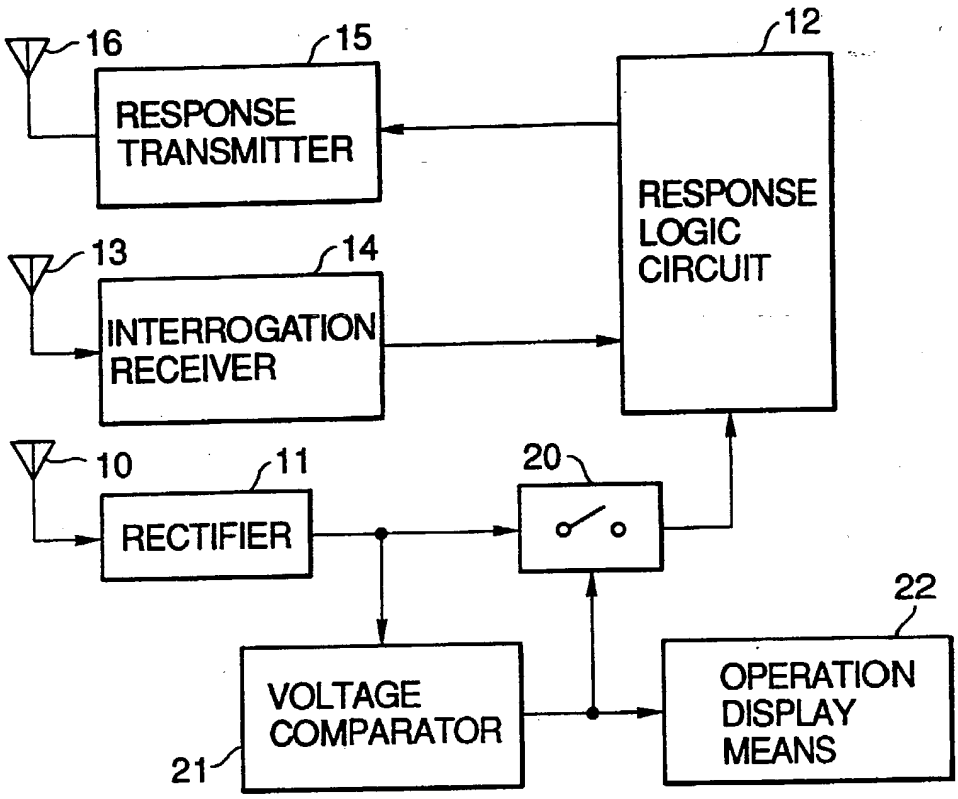
16
15
12
RESPONSE TRANSMITTER
RESPONSE LOGIC CIRCUIT
13
14
INTERROGATION RECEIVER
10
11
20
RECTIFIER
22
VOLTAGE COMPARATOR
OPERATION DISPLAY MEANS
21

FIG.2

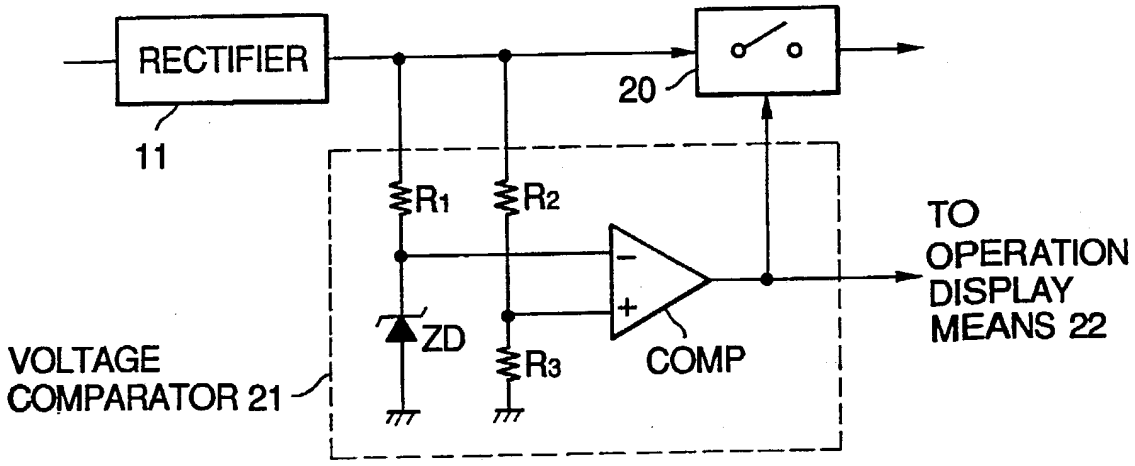
RECTIFIER
11
20
R1
R2
ZD
R3
COMP
TO OPERATION DISPLAY MEANS 22
VOLTAGE COMPARATOR 21

FIG.3

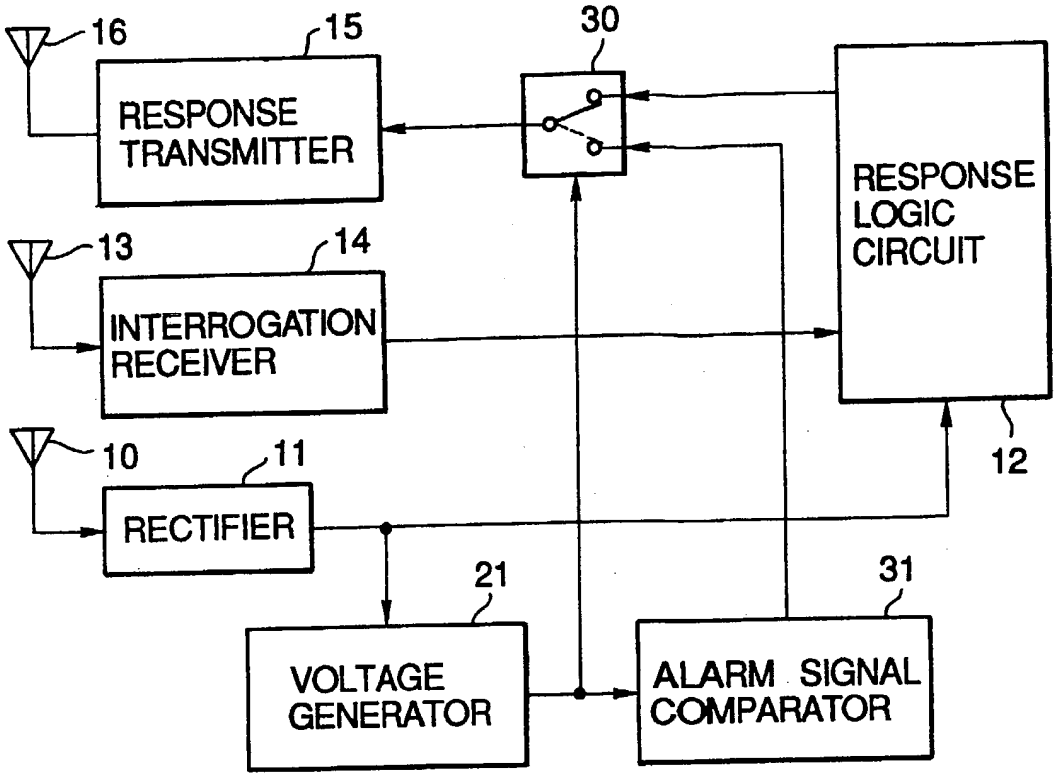
16
15
30
RESPONSE TRANSMITTER
RESPONSE LOGIC CIRCUIT
13
14
INTERROGATION RECEIVER
10
11
RECTIFIER
12
21
31
VOLTAGE GENERATOR
ALARM SIGNAL COMPARATOR

FIG.4

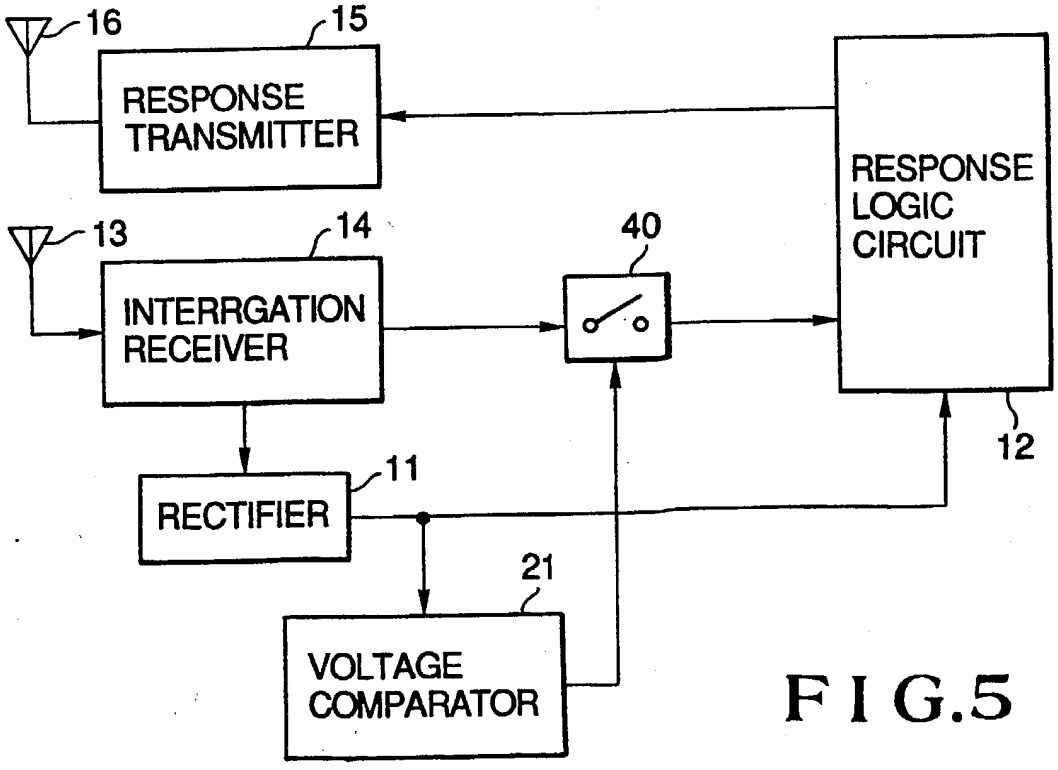
16
15
RESPONSE TRANSMITTER
RESPONSE LOGIC CIRCUIT
13
14
40
INTERRGATION RECEIVER
12
11
RECTIFIER
21
VOLTAGE COMPARATOR

FIG.5

Radio Transponder Apparatus in Transponder System

The present invention relates to a radio transponder apparatus in a transponder system, for causing a rectifier to convert a received radio wave into a DC power to use the power as a drive power source for a response logic circuit.

In recent years, the following transponder system has been proposed. In this transponder system, a radio transponder apparatus is carried by a user or attached to a moving unit. For example, proper data of the user or the moving unit is stored in the radio transponder apparatus. An interrogation signal is transmitted from a fixed radio interrogation apparatus to the radio transponder apparatus using a microwave, and the radio transponder apparatus which receives the interrogation signal transmits a proper response signal to the radio interrogation apparatus using the microwave. The radio interrogation apparatus verifies the received response signal by a proper means, and hence the user or the moving unit can be identified. In accordance with personal data stored in the radio transponder apparatus, the radio transponder apparatus can be used as an ID card or a driver's license. On the other hand, assume that, in, e.g., a manufacturing factory for

producing various types of products in small quantities, a radio transponder apparatus which stores specification data is attached to a semi-product on a manufacturing line. If the specification is interrogated from a fixed radio interrogation apparatus to the radio transponder apparatus during each process, and an operation is performed in accordance with this specification, the radio transponder apparatus can be used as an electronic specification instruction.

When the radio transponder apparatus is used as the above-mentioned ID card or driver's license, it is inconvenient if a drive power is supplied from a commercial AC power source in consideration of carriage or movement. If a drive power is supplied from a battery, a small and light radio transponder apparatus having a long service life cannot be provided.

A technique for causing a radio transponder apparatus to receive a microwave transmitted from an external radio interrogation apparatus to the radio transponder apparatus, causing a rectifier to convert the received radio wave into a DC power, and utilizing the energy as a drive power source for a response logic circuit is disclosed in Japanese Patent Laid-Open (Kokai) Nos. 56-140486 and 63-54023. The conventional system including a radio transponder apparatus and a radio interrogation apparatus disclosed in the above papers will

be briefly described hereinafter with reference to a block diagram in Fig. 1.

Referring to Fig. 1, a radio interrogation apparatus 1 includes an energy transmitter 2, and a non-modulated energy wave f_1 is transmitted from an antenna 3 to a radio transponder apparatus 4. The interrogation apparatus 1 further includes an interrogation logic circuit 5, and an interrogation signal is output from the interrogation logic circuit 5 to an interrogation transmitter 6. The interrogation signal is then transmitted from the interrogation transmitter 6 to the radio transponder apparatus 4 through an antenna 7 as an interrogation signal wave f_2. In addition, the radio interrogation apparatus 1 includes an antenna 8 for receiving a response signal wave f_3 transmitted from the radio transponder apparatus 4. The response signal is demodulated from the response signal wave f_3 received by the antenna 8 using a response receiver 9, and the demodulated signal is supplied to the interrogation logic circuit 5. In the interrogation logic circuit 5, it is discriminated whether the response signal from the radio transponder apparatus 4 is optimal with respect to the transmitted interrogation signal, and then, if optimal, an operation signal or the like is output to perform an operation in response to the response signal.

The radio transponder apparatus 4 includes an antenna 10 for receiving the energy wave f_1 transmitted

from the antenna 3. The energy wave f_I received by the antenna 10 is converted into a DC power by a rectifier 11, supplied to a power source terminal of a response logic circuit 12, and used as a drive power source. In addition, an antenna 13 is arranged to receive the interrogation signal wave f_2 transmitted from the antenna 7. The interrogation signal is demodulated from the interrogation signal wave f_1 received by the antenna 13 by an interrogation receiver 14, and the demodulated signal is supplied to the response logic circuit 12. In addition, a response signal output from the response logic circuit 12 is supplied to a response transmitter 15, and is transmitted from an antenna 16 to the radio interrogation apparatus 1 as the response signal wave f_3. The response logic circuit 12 properly performs an arithmetic operation in accordance with memory data in response to the interrogation signal to output the response signal, or a memory content is updated in response to the interrogation signal.

In the above-mentioned radio transponder apparatus 4, when a distance to the radio interrogation apparatus 1 is increased, an electric field intensity of the energy wave f_1 which can be received by the radio transponder apparatus 4 is weakened. A capacity of the DC power output from the rectifier 11 is also decreased, and a minimum voltage for allowing an optimal operation of the response logic circuit 12 cannot be obtained. Thus, when a

voltage for an optimal operation is not supplied and the response logic circuit 12 is operated, an operation error is easily caused. In response to an erroneous arithmetic operation, an erroneous response signal may be output, or a memory content may be erroneously updated. In particular, when the memory content is erroneously updated, an erroneous response signal is output in accordance with the erroneous memory content even if the circuit is normally operated after the update operation.

It is, therefore, an object of the present invention to provide a radio transponder apparatus for a transponder system which operates correctly in response to a received radio wave.

It is another object of the present invention to provide a radio transponder apparatus for a transponder system for allowing visual or audible confirmation that the apparatus can or is operating correctly.

In order to achieve the above objects, according to the present invention, there is provided a radio transponder apparatus for causing a rectifier to convert a received radio wave into a DC power to use the power as a drive power source for a response logic circuit, comprising a voltage comparator for comparing an output voltage from the rectifier with a predetermined minimum operating voltage, and a controller controlled in response to an output from the voltage comparator, the controller

activating one of components which constitute the apparatus to start a response operation when the output voltage from the rectifier is the minimum operating voltage or more. One of the components is, e.g., a response logic circuit. When the output voltage from the rectifier is a minimum operating voltage or more, the controller supplies a DC power to the response logic circuit through a switch arranged at an output side of the rectifier. Another one of the components is a response transmission system. More specifically, the controller may be arranged such that a response signal output from the response logic circuit is supplied to the response transmitter through the switch when the output voltage from the rectifier is the minimum operating voltage or more. The controller may be arranged such that an alarm signal output from an alarm signal generator is supplied to the response transmitter when the output voltage from the rectifier is lower than the minimum operating voltage.

The controller may be arranged such that an interrogation signal output from the interrogation receiver is supplied to the response logic circuit through the switch when the output voltage from the rectifier is the minimum operating voltage or more.

In addition, an operation display means controlled in response to an output from the voltage comparator may be arranged and driven when the output voltage from the rectifier is the minimum operating voltage

or more, or is lower than than the minimum operating voltage.

Fig. 1 is a schematic block diagram showing a conventional system including a radio transponder apparatus and a radio interrogation apparatus;

Fig. 2 is a block diagram showing a radio transponder apparatus according to an embodiment of the present invention;

Fig. 3 is a circuit diagram showing a detailed arrangement of a voltage comparator in Fig. 2;

Fig. 4 is a block diagram showing a radio transponder apparatus according to another embodiment of the present invention; and

Fig. 5 is a block diagram showing a radio transponder apparatus according to still another embodiment of the present invention.

Embodiments of the present invention will be described below with reference to Figs. 2 and 3. Fig. 2 is a block diagram showing a radio transponder apparatus according to an embodiment of the present invention, and Fig. 3 is a circuit diagram showing a detailed arrangement of a voltage comparator in Fig. 2. The reference numerals in Figs. 2 and 3 denote the same circuit blocks in Fig. 1.

A radio transponder apparatus shown in Fig. 1 includes an antenna 10 for receiving an energy wave f_1

transmitted from a radio interrogation apparatus. The energy wave f_1 received by the antenna 10 is converted into a DC power by a rectifier 11. The converted power is supplied to a power source terminal of a response logic circuit 12 through a power source controller 20 serving as a switch, and used as a drive power source.

An output from the rectifier 11 is supplied to a voltage comparator 21, and compared with a predetermined minimum operating voltage. The comparison result is supplied to an operation display means 22. For example, when the apparatus is operated, a lamp is turned on, or a proper visual or audible operation indication is provided. When the output from the rectifier 11 is lower than the minimum operating voltage, a visual or audible operation indication whose mode is different from that of the above-mentioned operation indication may be performed. Note that the switch used as the power source controller 20 is of a type having a control terminal. The operation display means 22 is constituted by, e.g., an LED or a buzzer.

An antenna 13 for receiving an interrogation signal wave f_2 transmitted from the radio interrogation apparatus is arranged. An interrogation signal is demodulated from the interrogation signal wave f_1 received by the antenna 13 by an interrogation receiver 14, and supplied to the response logic circuit 12. In addition, a response signal output from the response logic circuit 12

is supplied to a response transmitter 15, and is transmitted from an antenna 16 to the radio interrogation apparatus as a response signal wave f_3. The response logic circuit 12 properly performs an arithmetic operation in accordance with memory data in response to the interrogation signal so as to output the response signal, or the memory content is updated in response to the interrogation signal.

The radio transponder apparatus in Fig. 2 is different from the radio transponder apparatus 4 in Fig. 1 as follows. In Fig. 2, a DC power output from the rectifier 11 is supplied to the power source terminal of the response logic circuit 12 through the power source controller 20, and is supplied to the voltage comparator 21. In the voltage comparator 21, the output voltage from the rectifier 11 is compared with the predetermined minimum operating voltage, and the resultant output is supplied to the power source controller 20 and the operation display means 22.

The voltage comparator 21 is arranged, as shown in Fig. 3. On the output side of the rectifier 11, a series circuit of a resistor R_1 and a Zener diode ZD is grounded in parallel with a series circuit of resistors R_2 and R_3. In addition, divided voltages at a connecting point between the resistor R_1 and the Zener diode ZD and a connecting point between the resistors R_2 and R_3 are respectively supplied to the input terminals of a

differential amplifier COMP, and an output from the output terminal of the differential amplifier COMP is supplied to the power source controller 20 and the operation display means 22.

When the divided voltage obtained by dividing the output voltage from the rectifier 11 by the resistors R_2 and R_3 is lower than a Zener voltage of the Zener diode ZD, the differential amplifier COMP outputs a voltage set at "L" level, and the power source controller 20 is disabled. When the output voltage from the rectifier 11 is increased and the voltage divided by the resistors R_2 and R_3 becomes higher than the Zener voltage, the output from the differential amplifier COMP is inverted into "H" level. The power source controller 20 is enabled, and a DC power output from the rectifier 11 is supplied to the response logic circuit 12 through the power source controller 20 as a drive power source. The operation display means 22 causes an LED to turn on or causes a buzzer to produce a sound in response to an output set at "H" level from the differential amplifier COMP. When the output voltage from the rectifier 11 is increased to be the minimum voltage for properly operating the response logic circuit 12 or more, the power source controller 20 is switched to an enabled state from a disabled state. The minimum operating voltage serving as a reference voltage for the switching operation is properly set in advance in accordance with the Zener

voltage of the Zener diode ZD and a dividing ratio of the resistors R_2 and R_3.

With such an arrangement, since the DC power is supplied from the rectifier 11 to the response logic circuit 12 when the output voltage from the rectifier 11 is the minimum operating voltage or more, an operation error due to an insufficient drive voltage is not caused. In addition, in accordance with a display operation performed by the operation display means 22, it can be easily discriminated whether the radio transponder apparatus 4 is located inside the range of an electric field intensity which allows an optimal operation in response to an interrogation from the radio interrogation apparatus 1.

The operation display means 22 may be arranged as follows. When the output voltage from the rectifier 11 is lower than the minimum operating voltage and does not allow an optimal operation of the response logic circuit 12, but is higher than "0", the LED is turned on or the buzzer is driven. Therefore, it is discriminated that the radio transponder apparatus is located outside the range of an optimal electric field intensity.

Fig. 4 is a block diagram showing a radio transponder apparatus according to another embodiment of the present invention. The same reference numerals in Fig. 4 denote the same circuit blocks as in Figs. 2 and 1, and a repetitive description thereof will be omitted.

The radio transponder apparatus in Fig. 4 is different from the radio transponder apparatus 4 shown in Fig. 1 as follows. In Fig. 4, a response signal output from a response logic circuit 12 is supplied to a response transmitter 15 through a response signal controller 30, and an output from a voltage comparator 21 is supplied to the response logic circuit 12 and an alarm signal generator 31. In addition, an alarm signal output from the alarm signal generator 31 is supplied to the response signal controller 30. The response signal controller 30 is of a 2-input switching type with a control terminal. As the functions of the response signal controller 30, a response signal from the response logic circuit 12 is supplied to one connecting terminal, the alarm signal output from the alarm signal generator 31 is supplied to the other connecting terminal, and a signal of a common connecting terminal is supplied to the response transmitter 15. In addition, in the response signal controller 30, when an output from the voltage comparator 21 is set at "H" level, one connecting terminal for receiving the response signal is connected to the common terminal, as indicated by a solid line in Fig. 4. When the output from the voltage comparator 21 is set at "L" level, the other connecting terminal for receiving the alarm signal is connected to the common terminal, as indicated by a broken line in Fig. 4. The alarm signal generator 31 generates an alarm signal when the output from the voltage comparator 21 is set at "L"

level. The alarm signal generator 31 and the response transmitter 15 perform an optimal operation even if the operating voltage is lower than the minimum operating voltage of the response logic circuit 12.

With such an arrangement, when the output voltage from a rectifier 11 is lower than the minimum operating voltage, and is lower than a voltage which allows an optimal operation of the response logic circuit 12, an alarm signal is supplied to the response transmitter 15 in place of the response signal which may be an erroneous signal, and is transmitted to a radio interrogation apparatus 1 as a response signal wave f_3. The radio interrogation apparatus 1 receives the alarm signal to easily discriminate that the radio transponder apparatus 4 is located outside the range of a the optimal field intensity.

Note that the alarm signal generator 31 may be omitted to transmit neither an alarm signal nor a response signal when the output voltage from the rectifier 11 is lower than the minimum operating voltage. In this case, the radio interrogation apparatus 1 can discriminate that the radio transponder apparatus 4 is located outside the range of an optimal electric field intensity because the response signal is not supplied from the radio transponder apparatus 4.

Regardless of the presence/absence of the alarm signal generator 31, even if the response signal is not

transmitted and the response logic circuit 12 is erroneously operated because of a low drive voltage when the output voltage from the rectifier 11 is lower than the minimum operating voltage, an erroneous response signal is not transmitted.

Fig. 5 is a block diagram showing a radio transponder apparatus according to still another embodiment of the present invention. The same reference numerals in Fig. 5 denote the same circuit blocks as in Figs. 2 and 1, and a repetitive description thereof will be omitted.

A radio transponder apparatus in Fig. 5 is different from the radio transponder apparatus 4 shown in Fig. 1 as follows. In Fig. 5, an interrogation signal output from an interrogation receiver 14 is supplied to a response logic circuit 12 through an interrogation signal controller 40 serving as a switch with a control terminal. A subcarrier of an interrogation signal wave f_2 is converted into a DC power by a rectifier 11. The converted power is supplied to a power source terminal of the response logic circuit 12, and supplied to a voltage comparator 21. In addition, an interrcgation signal controller 40 is controlled in response to an output from the voltage comparator 21. When the output from the voltage comparator 21 is set at "H" level, the interrogation signal controller 40 is enabled and supplies an interrogation signal to the response logic circuit 12.

With such an arrangement, when the output from the rectifier 11 is lower than the minimum operating voltage, the interrogation signal is not supplied to the response logic circuit 12. Therefore, an erroneous update operation of a memory content due to a low drive voltage can be prevented. The embodiment shown in Fig. 5 is suitable for a case wherein an energy wave f_1 is not transmitted from the radio interrogation apparatus 1, but only the interrogation signal wave f_2 is transmitted.

Note that the energy wave f_1 is received and converted into a DC power in the embodiments shown in Figs. 2 and 4 and the prior art shown in Fig. 1, and the subcarrier of the interrogation signal wave f_2 obtained by the interrogation receiver 14 through the antenna 13 is converted into a DC power and used as a drive power source for the response logic circuit 12 in the embodiment shown in Fig. 5. However, the received radio wave to be converted into a DC power and used as a drive power source is not limited, as a matter of course.

Since the present invention has the above-mentioned arrangement, the following effects can be achieved.

When an electric field intensity of a received radio wave is weak and an output voltage from the rectifier is lower than the minimum operating voltage, a DC power is not supplied to the response logic circuit. Since the response logic circuit is not operated, an operation error

due to a low drive voltage is not caused. For this reason, in the radio transponder apparatus according to the present invention, transmission of a response signal and an update operation of a memory content are performed only when the apparatus is located inside the range of an electric field intensity which allows an optimal operation, thus obtaining highly reliable communication.

Assume that the electric field intensity of the received radio wave is weak and the output voltage from the rectifier is lower than the minimum operating voltage. If the response signal is not transmitted, transmission of an erroneous response signal can be prevented, thus improving reliability of communication. If an alarm signal is transmitted when the response signal is not transmitted, it can be easily discriminated on the radio interrogation apparatus side that the radio transponder apparatus is located outside the range of an electric field intensity which allows an optimal operation.

If transmission of the interrogation signal to the response logic circuit is prevented when the output from the rectifier is lower than the minimum operating voltage, an erroneous update operation of a memory content in response to the interrogation signal can be prevented.

In addition, when the operation display means displays whether the output voltage from the rectifier is the minimum operating voltage or more, it can be easily discriminated whether the radio transponder apparatus is

located inside or outside the range of an electric field intensity which allows an optimal operation. If necessary, the radio transponder apparatus can be moved closer to the radio interrogation apparatus.

What is claimed is:

1. A radio transponder apparatus in a transponder system for causing a rectifier to convert a received radio wave into a DC power to use the power as a drive power source for a response logic circuit, comprising a voltage comparator for comparing an output voltage from said rectifier with a predetermined minimum operating voltage, and a controller controlled in response to an output from said voltage comparator, said controller activating one of components which constitute said radio transponder apparatus to start a response operation when an output voltage from said rectifier is not less than the minimum operating voltage.

2. An apparatus according to claim 1, wherein one of said components is a response logic circuit, and said controller comprises means for supplying a DC power which is an output from said rectifier to said response logic circuit as a drive power source in response to an output from said voltage comparator obtained when an output voltage from said rectifier is not less than the minimum operating voltage.

3. An apparatus according to claim 1, wherein one of said components is a response transmission system, and said controller comprises means for connecting an output side of

said response logic circuit to said response transmission system in response to an output from said voltage comparator obtained when the output voltage from said rectifier is not less than the minimum operating voltage.

4. An apparatus according to claim 3, further comprising an alarm signal generator, wherein said controller comprises means for supplying an alarm signal output from said alarm signal generator to said response transmission system when the output voltage from said rectifier is lower than the minimum operating voltage.

5. An apparatus according to claim 1, further comprising an interrogation receiver for receiving an interrogation, wherein one of said components is a response logic circuit, and said controller receives an interrogation signal output from said interrogation receiver to said response logic circuit when the output voltage from said rectifier is not less than the minimum operating voltage.

6. An apparatus according to claim 1, wherein one of said components is operation display means, and said controller drives said operation display means when the output voltage from said rectifier is not less than or less than the minimum operating voltage.

7. An apparatus according to claim 1, further comprising an interrogation receiver for receiving an interrogation signal wave from said radio interrogation apparatus, wherein said rectifier converts a subcarrier of the interrogation signal wave into a DC power.

8. An apparatus according to claim 1, further comprising means for receiving an energy wave from said radio interrogation apparatus, wherein said rectifier converts the energy wave into a DC power.

9. A radio transponder apparatus substantially as described herein with reference to Figs. 2 to 5 of the accompanying drawings.

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